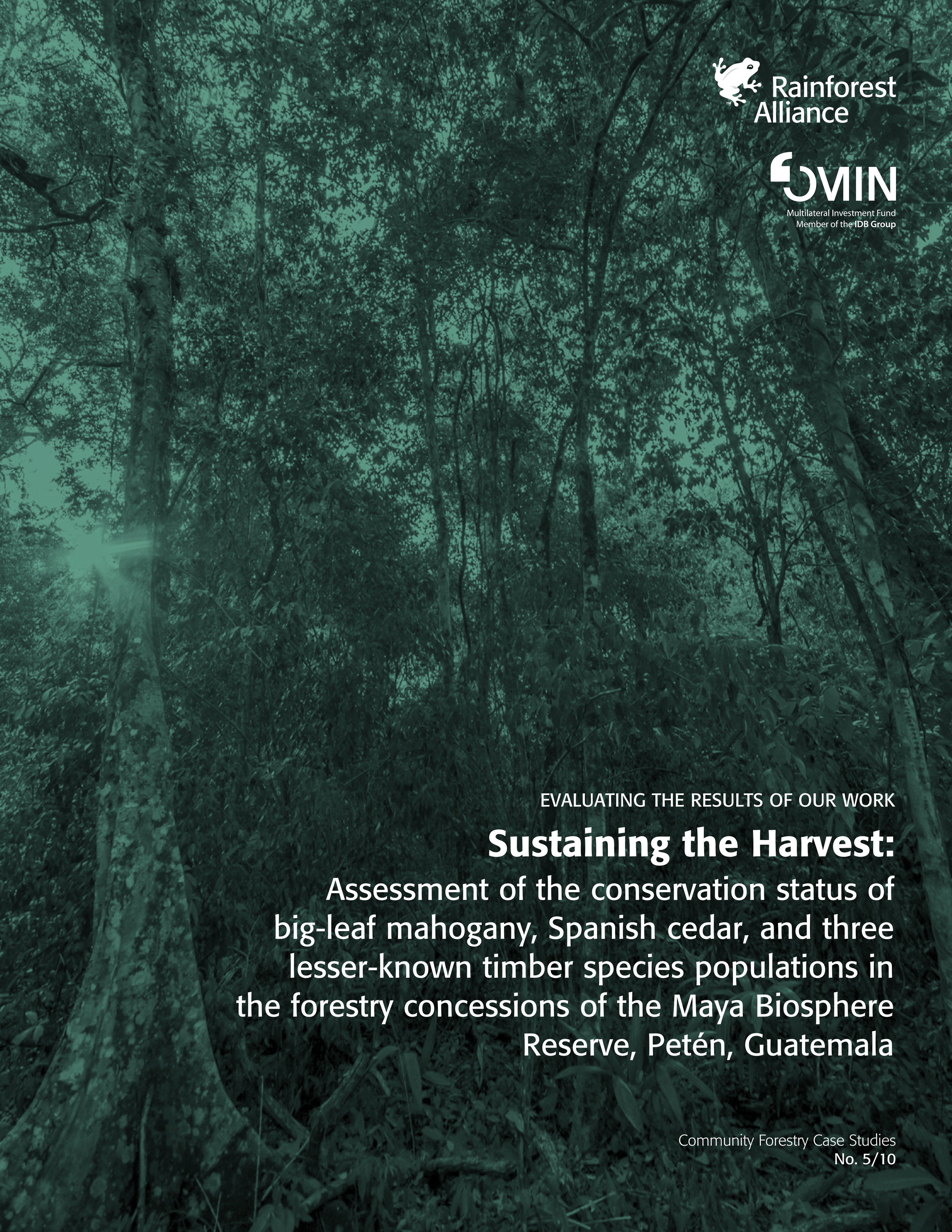

Rainforest Alliance

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EVALUATING THE RESULTS OF OUR WORK

Sustaining the Harvest:

Assessment of the conservation status of big-leaf mahogany, Spanish cedar, and three lesser-known timber species populations in the forestry concessions of the Maya Biosphere Reserve, Petén, Guatemala

Community Forestry Case Studies
No. 5/10

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The Multilateral Investment Fund (MIF), a member of the Inter-American Development Bank (IDB) Group, is the largest provider of technical assistance for private-sector development in Latin America and the Caribbean. Its core beneficiaries include micro and small businesses, small farms, and poor and vulnerable households. It designs and finances pilot projects to test pioneering approaches to building economic opportunity and decreasing poverty.

The Rainforest Alliance works to conserve biodiversity and ensure sustainable livelihoods by transforming land-use practices, business practices and consumer behavior. www.rainforest-alliance.org

Contents

Acronyms

AAA	Annual Harvest Area
ACOFOP	Association of Petén Forest Communities
CATIE	Tropical Agricultural Research and Higher Education Center
CFE	Community Forest Enterprise
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CONAP	National Council on Protected Areas
DBH	Diameter at Breast Height
FORESCOM	Community Forestry Services Enterprise
FSC®	Forest Stewardship Council®
FYDEP	Petén Development Promotion State Enterprise
MBR	Maya Biosphere Reserve
MDCL	Minimum Diameter Cutting Limit
MIF	Multilateral Investment Fund (member of Inter-American Development Bank Group)
MUZ	Multiple Use Zone
POAF	Annual Operational Forest Plan
USAID	United States Agency for International Development

PREFACE

Over the last two decades, countries across the tropics have devolved increasing authority over natural forests to local actors. The ability of those actors to manage forests sustainably and make forestry a competitive land-use choice has therefore taken on a growing importance. In response to this changing landscape, a range of efforts around the globe are supporting community-based forest management by working to improve the capacity of local people to manage their natural resources and develop local enterprise. In spite of the abundance of manuals, methodologies and other tools to guide technical assistance, there is a relative paucity of systematic analyses of the results of such efforts: experiences, lessons learned and recommendations for improving assistance to local forestry development.

This case study is one of 10 produced under "Forest Conservation through Certification, Markets and Strengthening of Small and Medium-sized Forest Enterprise," a five-year project supported by the Multilateral Investment Fund (MIF), a member of the Inter-American Development Bank (IDB) Group. Led by the Rainforest Alliance, the project involves approximately 100 community operations and small and medium-sized enterprises (SMEs) in Guatemala, Honduras, Mexico, Nicaragua and Peru. The project's central aim is to improve local livelihoods through sustainable forestry and enterprise development. Although the support needs, contexts and development levels of partner communities vary tremendously, the project's unifying strategy is to improve business capacities, market access and financial support for enterprise development in order to secure sustainable forest management and livelihood development.

The case studies in this series were carefully selected to cover all five countries where the project is active, and to reflect the full range of participants—from highly incipient community operations, to second-tier business alliances among multiple well-developed, certified enterprises. Special attention was also paid to ensuring representativeness with respect to forest ecosystems (temperate and tropical), tenure arrangement (permanent and concession) and production focus (timber and non-timber). In all of the studies, the impact of Rainforest Alliance technical assistance on enterprise development was analyzed, including a critical assessment of priorities for future assistance. Beyond enterprise-specific examples, two studies take a more thematic approach, analyzing experiences with markets for lesser-known species and financial mechanisms.

Taken together, the 10 studies support the growing body of research demonstrating that community-based production forestry can be an effective approach to conserving forest resources while also generating significant social and economic benefits for marginalized communities. At the same time, however, these studies tell a more nuanced story. The diversity of contexts and enterprises represented sheds light on the development of community forestry in its many forms—towards multiple and sometimes contested goals—while chronicling both successes and failures. As such, each case stands on its own to inform similar cases around the world, while also forming a part of the broader story this series tells about the variable trajectories of community forestry development.

Although a guiding goal of many projects—including the present one—is to achieve financial sustainability for community forest enterprise, the importance of external technical assistance in building local capacities is also clearly fundamental. However, the effectiveness of such assistance is not always optimal, which is why each case includes an assessment of the results of the Rainforest Alliance technical assistance that was received. In several cases, insufficient data and/or a lack of indicator consistency—not to mention confounding external factors (storms, market fluctuations, political upheaval and social conflict) and the absence of truly scientific controls—make it impossible with full confidence to attribute change solely to Rainforest Alliance support, especially given the active presence of other actors at all project sites. This caveat notwithstanding, it is clear that, in each case, project interventions produced concrete results. The studies aim to extract lessons from these results and recommend ways forward.

Finally, while the bulk of these studies have been prepared and published by staff of the Rainforest Alliance, they would not have been possible without the collaboration and dedicated efforts of many others including a host of government agencies, civil society partners, academic institutions and private sector actors. Above all, the communities themselves must be recognized and congratulated for the time that they invested in assisting with the compilation and review of these studies. All contributors are specifically acknowledged in each separate case study. Although the contributions of all of these actors are fundamental, the content of these studies is the sole responsibility of the Rainforest Alliance, except where other institutions have taken a co-publishing role.

The table on the following page presents a breakdown of the 10 case studies that were produced as part of this project.

Community forestry case studies

No.	Case Study	Location	Key Themes
1	Awas Tingni community	North Atlantic Autonomous Region, Nicaragua	• Indigenous community forestry • Incipient forest enterprise development • Social and institutional foundations for community forestry
2	Moskibatana non-timber forest product (NTFP) enterprise	Muskitia, Honduras	• Indigenous community forestry • NTFP management and Forest Stewardship Council® (FSC®) market development • Development of a new forest enterprise
3	Ejido El Largo	Chihuahua, Mexico	• Integrated forestry development planning • Community forest enterprise competitiveness
4	CAIFUL agroforestry cooperative	Río Plátano Biosphere Reserve, Honduras	• Local forest enterprise development • Benefits of forest enterprise at the community scale
5	Analysis of forest management in community concessions	Maya Biosphere Reserve, Guatemala	• Impacts of certified community forestry silvicultural and management systems • Investments by community enterprises in conservation and monitoring
6	Brazil nut production and enterprise	Madre de Dios, Peru	• NTFP enterprise development • Financial and administrative capacity building
7	TIP Muebles	Oaxaca, Mexico	• Commercial cooperation among community forest enterprises • Furniture value chain development
8	Tres Islas native community	Madre de Dios, Peru	• Indigenous community forestry • Landscape approach • Incipient forest enterprise development
9	Building markets for lesser-known species	Maya Biosphere Reserve, Guatemala	• Development of new markets for lesser-utilized commercial timber species • Diversification of a second-tier community forestry business model
10	Financial mechanisms for community forest enterprises	Regional	• Design, operation and impacts of mechanisms to increase forestry producer access to credit

EXECUTIVE SUMMARY

Sustaining the Harvest:

Assessment of the conservation status of big-leaf mahogany, Spanish cedar, and three lesser-known timber species populations in the forestry concessions of the Maya Biosphere Reserve, Petén, Guatemala

Grading and scaling at a log landing in the MBR

Photo by Sergio Izquierdo

Ensuring the sustainability of forest harvesting is a cornerstone for developing competitive community forest enterprises (CFEs). Without continued availability of the forest products upon which an enterprise relies, there can be no adequate long-range planning or growth, nor can any economic or conservation benefits be reasonably sustained. While many CFEs collect data on forest growth, relatively few have the capacity to incorporate such data into management planning and silvicultural approaches. Even fewer have the capacity to undertake detailed assessments of the impacts of forest harvesting on timber species population recovery and future commercial production. This case study documents the findings of an investigation carried out in the forestry concessions in the Maya Biosphere Reserve (MBR) in the department of Petén, Guatemala, assessing post-harvest population and production recovery of the five timber species that sustain the region's CFEs, as well as two industrial concessions.

Covering close to 2.1 million hectares, the MBR is the largest protected area in Central America and home to about 180,000 people, as well as globally important biodiversity and cultural heritage. Established in 1990, the reserve is also the site of an internationally significant example of multiple-use forest management with the twin aims of conservation and social development. The MBR is divided into three different zones allowing for varying degrees of resource management: (1) the Core Zone (36% of the reserve), consisting of national parks and "biotopes," allowing only for scientific research and tourism; (2) the Multiple Use Zone (40%), in which low-impact natural resource management activities are allowed, and; (3) the Buffer Zone (24%), a 15-kilometer band along the southern border of the MBR, where a range of land management activities, including agriculture, are permitted.

In the Multiple Use Zone (MUZ), usufruct rights were granted by the Guatemalan government in the late 1990s and early 2000s to 12 community organizations and two private industrial firms to manage for timber and non-timber forest products. The decision to allow for concessions was a controversial one, since many doubted the ability of production forestry—particularly in the hands of community groups—to conserve natural forests. In order to achieve and maintain the concession contract, forestry concessions are required to comply with the standards of the Forest Stewardship Council (FSC). The Rainforest Alliance, among other local and international organizations, has been supporting the concessions since their establishment. In addition to the current project funded by IDB/MIF, significant support has come from USAID.

Some fifteen years after the majority of concessions were awarded, the conservation status of five of the most important timber species—big-leaf mahogany

(*Swietenia macrophylla*), Spanish cedar (*Cedrela odorata*), manchiche (*Lonchocarpus castilloi*), pucté (*Bucida buceras*), and santa maría (*Calophyllum brasiliense*)—was analyzed. Analysis was based on available inventory and logging data, as well as extensive field-based data collection in eleven concessions. Species' population recovery during cutting cycles after harvests was evaluated using variable modelling approaches developed with the most up-to-date scientific knowledge.

The core finding of this study is that timber harvesting in the MBR is sustainable, and in fact represents state-of-the-art best practice globally for species-level management in tropical forests. At present levels of harvesting, populations of commercially important timber species are expected to recover initial commercial densities and volumes during cutting cycles between successive harvests, on average. Such a finding, backed up by scientifically rigorous, field-based empirical data, sets the MBR apart from most other commercial forestry operations in the tropics.

This conclusion is particularly notable given that a majority of the concession area is under the management of communities whose capacities to implement sustainable forestry have been and continue to be questioned, both in Guatemala and across the tropics. The fact that community-based enterprises—working together with government and technical assistance agencies—are practicing better forest management than highly capitalized industrial firms operating in other parts of the tropics is a globally important finding. This is being achieved, moreover, in a context where deforestation pressures are notably high. The MBR model thus deserves recognition and replication in other tropical countries, particularly as greater areas of natural forest are coming under local control.

Beyond this central finding, the analysis finds that:

- MBR concessions had the advantage of starting with highly favorable mahogany densities and population structures across much of the landscape, operating in a place where site conditions favor species population recovery.
- The Guatemalan agency in charge of the MBR's administration—CONAP, by its Spanish acronym—requires concessions to base cutting intensity on biological reality rather than arbitrary indicators or financial considerations; this practice is highly desirable and exceptionally rare in the world of tropical forestry.
- With a high degree of certainty, mahogany populations will recover pre-harvest commercial densities during the first cutting cycle between harvests, on average. This outcome appears sustainable over repeated harvests under current forest management practices in the MUZ.
- Spanish cedar populations occurring at extremely low landscape-scale densities should recover pre-harvest commercial densities during the first cutting cycle, but volume production will be much lower during second harvests compared to first harvests.
- Most manchiche, pucté, and santa maría populations should also recover pre-harvest commercial densities during the first cutting cycle. Volume production will be lower, on average, during second harvests compared to first harvests, but the decline will not be as extreme as for Spanish cedar.
- Harvest operations appear to encourage seedling establishment and short-term post-harvest growth.
- The data from permanent monitoring plots within the concessions is valuable but not sufficient to guide fully informed decision-making.

Based on these findings, the following recommendations are advanced:

- Ensure that incentives for long-term management are in place by extending the length of concession contracts through multiple cycles—the Guatemalan government should extend concession contracts beyond the current 25-year horizon to encourage even greater stability and sustainability in planning and investment.
- Improve knowledge of species' regeneration and recruitment requirements – while mahogany regeneration ecology is fairly well understood, knowledge is lacking for *Cedrela, Lonchocarpus, Bucida*, and *Calophyllum*, which are likely to become more important to CFEs as markets expand for these species.
- Silvicultural practices designed to reduce mortality and increase growth rates by commercial, future crop, and juvenile trees should be implemented. Currently, the sole silvicultural practice is tree-felling itself; pre- and post-harvest vine cutting to free the crowns of commercial species is the single most effective way to reduce mortality and accelerate long-term diameter growth rates.
- Improve the network of permanent monitoring plots in order to increase the accuracy of cutting intensity calculations and the predictive power of model simulations for all species.
- Systematic sampling of juvenile stems (seedlings, saplings, pole-sized trees) and use of a tailored, user-friendly version of the model applied here should be incorporated into annual management operations and decision-making.
- Implement target cutting intensities more consistently—approving extraction of extra volume from a "non-recoverable basal area" is likely to produce population declines over time; adjustments to cutting intensity should be approved with caution, if at all, and should be attached to requirements for silvicultural treatment that will accelerate recuperation of basal area.

View from above the canopy of the MBR

Photo by Sergio Izquierdo

Introduction

Situated in the Selva Maya—a tropical forest expanse spanning Belize, Guatemala and Mexico—the Maya Biosphere Reserve (MBR) anchors the largest block of broadleaf tropical forest in Mesoamerica (Map 1). Its nearly 2.1 million hectares are home to about 180,000 people and contain the vestiges of ancient Maya cities—most notably Tikal—a reminder that the area was once the heartland of the Maya Civilization. The MBR also houses a wide array of globally-important biodiversity and wildlife species, including jaguar, puma, tapir and scarlet macaw. Beyond iconic fauna, the MBR's ecosystems are home to the high-value timber trees *Swietenia macrophylla* (big-leaf mahogany, locally known as 'caoba') and *Cedrela odorata* (Spanish cedar, locally known as 'cedro'). Both species have been listed since 2002 on CITES Appendices II and III, respectively, after decades of overharvesting throughout their native range in tropical America.

Since the 1990s, 14 forestry concessions have been granted within the MBR's Multiple-Use Zone (MUZ), of which nine community forest enterprises and two 'industrial' or private enterprises are active today (Table 1, Map 2). Their forest management activities are overseen by the Guatemalan government's National Council on Protected Areas (CONAP). The decision to grant these concessions was and remains controversial, since many doubted the capacity of production forestry to maintain forest cover and biodiversity values. Many stakeholders are thus interested in understanding the impacts that logging has had on the forest

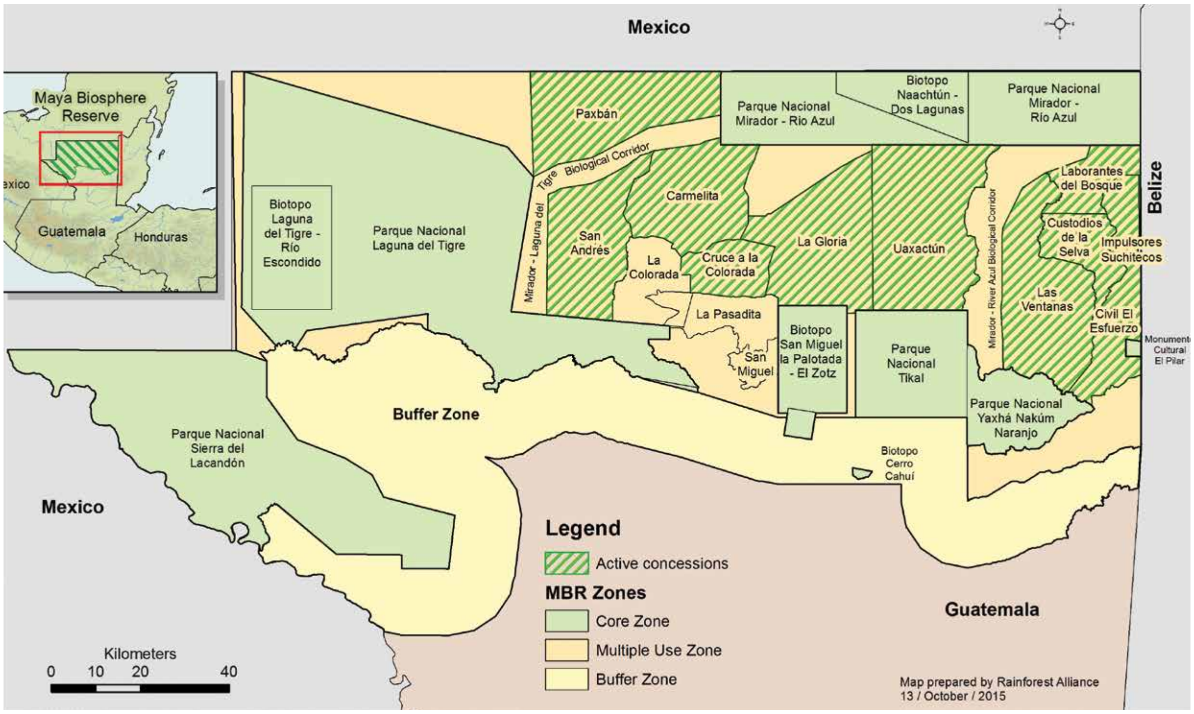


Figure 1 Map of MBR and forestry concessions

Table 1
Community and Industrial Concessions in the Multiple-Use Zone

No.	Management body	Concession name	Area (Ha)
Community concessions			
1	A. de P. San Miguel la Palotada*	San Miguel	7,039
2	A. de P. La Pasadita*	La Pasadita	18,817
3	Cooperativa Carmelita, R.L.	Carmelita	53,797
4	S.C. Impulsores Suchitecos	Río Chanchic	12,218
5	S.C. Laborantes del Bosque	Chosquitán	19,390
6	S.C. Organización Manejo y Conservación (OMYC)	Uaxactún	83,558
7	Asociación Forestal Integral San Andrés, Petén (AFISAP)	San Andrés	51,940
8	S.C. Árbol Verde	Las Ventanas	64,973
9	Asociación Forestal Integral La Colorada (AFIC)*	La Colorada	22,067
10	Asociación Forestal Integral Cruce a La Colorada (AFICC)	Cruce a La Colorada	20,469
11	S.C. Custodios de la Selva	La Unión	21,176
12	S.C. El Esfuerzo	Yaloch	25,386
Subtotal - Community concessions			400,830
Industrial concessions			
1	Baren Comercial Ltda.	La Gloria	66,460
2	Gibor, S.A.	Paxbán	65,755
Subtotal - Industrial concessions			132,215
Total forestry concessions			**533,045**

A. de P. = Asociación de Producción; S.C. = Sociedad Civil; R.L. = Responsabilidad Limitada
*Concession cancelled

ecosystems of the MUZ—whether positive or negative—in order to evaluate the concession system in both ecological and economic terms. Only with an empirically based analysis of the impacts of forest harvesting can a truly informed discussion regarding the concessions' medium- and long-term viability be undertaken.

The financial model of the concessions has been heavily reliant on sales of mahogany and, to a lesser extent, Spanish cedar, although recent years have seen greater exploration and use of lesser-known species. In 2013, 55 percent of harvested volumes and 85 percent of community forest business income still came from these two species. Most of the remaining harvested volume (40 percent) came from three additional species: *Lonchocarpus castilloi* (locally known as 'manchiche'), *Bucida buceras* ('pucté'), and *Calophyllum brasiliense* ('santa maría'). A critical aspect of evaluating the viability of the MUZ forest management model in both ecological and financial terms is, therefore, understanding the resilience of these species' populations under current harvest practices and intensities.

While a variety of studies have been conducted on mahogany and Spanish cedar in the MUZ, as of 2014 a comprehensive study at appropriate spatial and temporal scales to evaluate their conservation status had not been undertaken. Moreover, the design of existing long-term forest monitoring plots within concessions does not provide adequate sample size or data to answer questions about a given species' resilience under logging regimes (Marmillod 2012), although they can provide valuable information regarding a given tree species' life cycle. Nor have any studies attempted to project current distribution and density patterns into the future in order to understand the long-term implications of today's management decisions.

The primary actors in the MUZ—community and private concessionaires, CONAP, and technical assistance providers—therefore identified a need to analyze the conservation status and impacts of current harvest practices on populations of mahogany, Spanish cedar and the three commercially significant lesser-known species with a view to ensuring their long-term health. The present study was led by CATIE in collaboration with Rainforest Alliance, the Association of Peten Forest Communities (ACOFOP), FORESCOM (a processing and sales service provider to the community enterprises), and CONAP.

Forest management in the MBR

Some level of selective mahogany logging has probably occurred in Petén for several centuries, but the 1960s through the 1980s saw a particularly intensive period of exploitation. Under the watch of a largely military-administered state enterprise called Fomento y Desarrollo del Petén (FYDEP), 13 logging companies were given 3- to 5-year renewable contracts to log as much as they could, paying a simple volume-based tax. Anecdotal sources suggest logging intensities of up to six mahogany trees per hectare were common in at least certain areas of what is now the Reserve.[1]

The FYDEP system of forest harvest licenses ended in 1989. All logging contracts were revoked with the Biosphere Reserve's creation the following year. Although the regulations creating the MBR in 1990 allowed for the possibility of granting concessions, the process of negotiating them took time. Most of the CFEs began logging under 25-year contracts only in the early 2000s. Substantial donor support from USAID and technical assistance from Rainforest Alliance and CATIE, among others, played a notable role in this process (Kent et al. 2014).

Between 2000 and 2013, fourteen concessions extracted 284,555 m^3 of timber at an average intensity of 2.16 m^3 ha^{-1}. Eleven concessions remained active as of late 2014: nine community forest concessions occupy 352,907 ha (73 percent of the total concession area), while two private concessions cover 132,303 hectares (23 percent).

CONAP is the regulatory entity for forest management in the MUZ under the Protected Areas Law Decree 4-89 (Article 19) and Forest Law Decree 101-96. Over the years, regulations have been adjusted in response to concerns and needs as these have emerged; regulations are detailed in the "Protected Area Forestry Administration Manual". All concessions in the MUZ are required to elaborate and operate according to three nested sets of plans prepared with assistance from their regent, a professional forester certified by the national forester's guild who is legally responsible for ensuring proper execution of planning and harvest:

- *Management Plan:* A long-term plan covering the entire management area, corresponding to the length of the cutting cycle (25-40 years), prepared with assistance from a professional forester. The management plan describes overall strategies for ecological and economic sustainability in the extraction of both timber and non-timber species.

- *Five-Year Plan:* An intermediate plan requiring concessions to define the boundaries of their next five annual harvesting parcels, estimating volumes and establishing a roughly equal annual distribution of volumes across a five-year block (which can result in annual harvest parcels of very different size). Complete commercial inventories (>30 cm DBH) are conducted within parcels that represent a 3%-area sample of the block.

- *Annual Operational Forest Plan (POAF in Spanish):* On a yearly basis the concession must submit a detailed plan for the annual harvest area (AAA in Spanish) or parcel. The POAF is a 100-percent-area and geo-referenced census or inventory of individuals of commercial trees larger than 30 cm diameter found in the AAA. The AAA excludes areas with steep slopes (exceeding 55 percent grade), seasonally flooded lowlands, water recharge zones, riparian areas, archeological sites, and other high conservation-value areas. Data is taken on DBH, stem quality, function (extract, future harvest, protect, salvage, decrepit, seed tree), and commercial height. Particularly healthy, well-formed and emergent individuals are left standing as 'seed trees'; there is no fixed requirement for how many must be left. The POAF must also include maps showing the location of all commercial trees (both current and future), planned skid roads, secondary and tertiary roads, and log landings.

Forest canopy emergent with regeneration in the understory

Photo by Sergio Izquierdo

Concession contracts signed with the Guatemalan government stipulate that these three plans, once approved by CONAP, must be followed; they also lay out the conditions for revoking a concession in the case of persistent non-compliance. These contracts also require that each enterprise have plans for management of natural regeneration, reforestation and/or restoration of timber resources, which may include activities such as enrichment planting.

In addition to the standards required by the Guatemalan government, all concessions must obtain and uphold FSC certification. This requirement was established in 1999 by CONAP in response to social and political pressures regarding the importance of using best practices when harvesting within protected areas such as the MBR. Seven community concessions operate under a group certification held by FORESCOM, while two community concessions and both industrial concessions have their own certificates. FSC audits are conducted annually, currently by RA-Cert (formerly SmartWood), historically one of the FSC certification bodies with the most experience in auditing community forestry operations.

CONAP conducts an inspection before approving the POAF to verify that mapped trees and volumes correspond to the AAA. A second inspection is conducted during logging to oversee harvest practices, and a third inspection occurs afterwards to verify that regulations and harvest parameters were upheld and that post-harvest practices, such as cleaning up skid trails, were followed. In all cases, CONAP uses a sampling methodology for these inspections. Via FSC audits, the concessionaires have to conduct post-harvest evaluations and monitor for impacts; their certification audit reports are publically available.

Study species

Swietenia macrophylla (big-leaf mahogany, *caoba* in Spanish, in the family Meliaceae) is the world's premier tropical timber species. It occurs in seasonally dry tropical forests from Mexico's Yucatan Peninsula to lowland forests of the Bolivian Amazon. Like most tropical tree species, *Swietenia* occurs at low landscape-scale densities which vary widely from region to region, and even within localities. Population densities in Central America, and especially in the great Selva Maya straddling Guatemala, Belize, and Mexico, tend to be much higher than in South America. *Swietenia* is a giant canopy emergent tree at maturity, capable of rapid vertical and diameter growth under optimal growing conditions, which include high light, high available soil nutrients, and deep, well-drained soil. Mahogany seeds are relatively large, winged, and wind dispersed during the dry season, typically landing on the forest floor within 100 meters of parent trees. Germination occurs rapidly after the onset of wet season rains. Seedling survival and growth depends mainly on light availability after establishment. While median diameter growth rates range from 0.3–0.7 cm year-1, sustained growth rates exceeding 1 cm year-1 are possible under optimal conditions.

Cedrela odorata (Spanish cedar or *cedro*, also in the family Meliaceae) is a close relative of mahogany with many similar timber and life history characteristics. It is a neotropical species whose range overlaps *Swietenia*'s while extending further into the Caribbean, east across northern Amazonia into the Guianas, and much further south into the Brazilian Atlantic forest and Argentina. Across its range *Cedrela* population densities tend to be lower than *Swietenia*'s, with exceptions (see, for example, high densities of *Cedrela* on steep topography at Tikal and adjacent forests). *Cedrela* is a large canopy emergent, possibly a faster grower than *Swietenia* under ideal conditions, which remain poorly understood, and probably shorter-lived. Its seeds are winged and wind dispersed but much smaller than *Swietenia* seeds, produced in much higher numbers, and dispersed over much greater distances and areas. Seed germination and seedling establish-

Table 2
Forest concessions participating in this study

No.	Concession name	Abbreviated name
1	Asociación Forestal Integral Cruce a la Colorada	AFICC
2	Asociación Forestal Integral San Andrés Petén	AFISAP
3	Sociedad Civil para el Desarrollo 'Árbol Verde'	Árbol Verde
4	Cooperativa Carmelita, R.L.	Carmelita
5	Sociedad Civil Laborantes del Bosque	Chosquitán
6	Baren Comecial Ltda.	La Gloria
7	Sociedad Civil Custodios de la Selva	La Unión
8	Gibor, S.A.	Paxbán
9	Sociedad Civil Impulsores Suchitecos	Río Chanchich
10	Sociedad Civil Organización, Manejo y Conservación (OMYC)	Uaxactún
11	Sociedad Civil El Esfuerzo	Yaloch

ment rates are low. Regeneration requirements are poorly understood.

Lonchocarpus castilloi (manchiche, in the family Fabaceae-Papilionoideae) is a tropical timber species whose natural range is restricted to southern Mexico and Central America. It is a medium-sized canopy overstory tree only occasionally exceeding 100 cm diameter. While typically associated with *Bucida burceras* (see Table 2) and Brosimum alicastrum (ramón, Moraceae) in seasonally dry forests, little published information is available about its population density patterns or life history.

Bucida burceras (pucté, Combretaceae) occurs from the Caribbean and southern Mexico to the Guianas across northern South America. Like Lonchocarpus it is a medium-sized canopy overstory tree. Bucida is a light-demanding tree that competes best on marginal sites where available soil moisture may limit growth by other species. For this reason, it is often associated with swales and seasonal streams in dry foothills. Based on data from concessions in this study, Bucida is a slow-growing relative to the other four species. Seeds are small (~38,000 per kg) with low germination capacity; dispersal mechanisms are poorly understood (Francis 1989). Little is known about size-specific mortality and growth rates.

Calophyllum brasiliense (santa maría, Clusiaceae) occurs from the Caribbean and Mexico to Peru, Bolivia, Brazil, and the Guianas. It is a relatively shade tolerant, medium-sized canopy overstory tree. Calophyllum is a site and soil generalist, generally occurring where annual rainfall totals exceed 1500 mm, growing best where conditions are wet and humid; it also tolerates excessively draining soils (Devall & O'Rourke 1998). Fruit and seeds are dispersed by bats, birds, rodents, and, in intermittently flooding forests, by fish. Like Lonchocarpus and Bucida, little is known about its size-specific mortality and growth rates.

Methods

This study relied on both historical data of logging activity in concessions and new fieldwork. One-hundred-percent-area inventory data for commercial and sub-commercial trees >30 cm diameter in 2005 and 2006 POAFs were obtained in digital format from CONAP, including indication of whether individual trees were harvested or not. In May–June 2014, 265 one-hectare strip transects were installed at 1-percent-area intensity within all POAFs in eleven concessions (Table 2, Map 3) to provide density estimates for seedlings, saplings, and pole-sized trees. These two sources provided the pre- and post-harvest population structure data necessary for modeling commercial recovery after one or more harvests.

Separate modeling platforms were used to analyze response by *Swietenia* on the one hand, and by *Cedrela* plus three lesser-known timber species on the other. The *Swietenia* model was adapted from a model constructed to evaluate the impact of current legal forest management practices on future harvests in Brazil (Grogan et al. 2014). This model is based on large-scale 20-year field studies of all phases of mahogany's life history, including size-related mortality, diameter growth, and fruit pro-

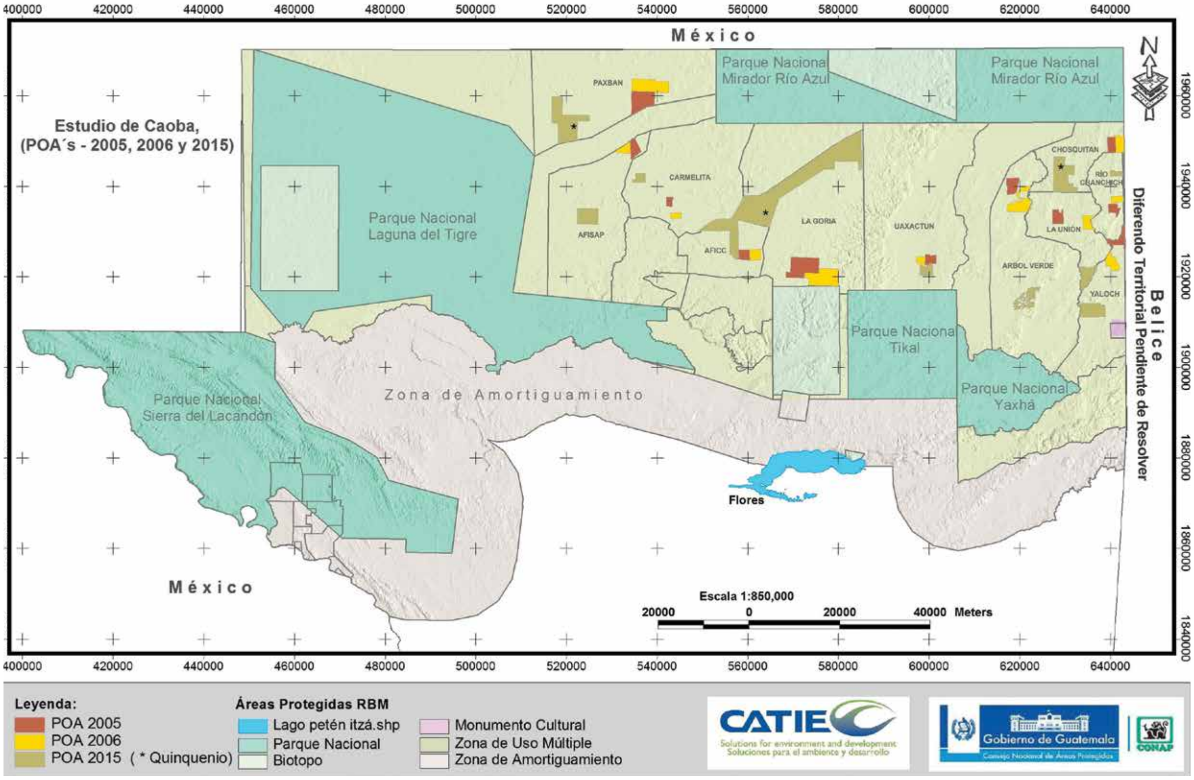


Figure 2
Location of 11 forest concessions participating in the study. Colored blocks within concessions indicate location of sampled POAFs

Map by CATIE and CONAP.

duction rates. The model simulates the harvesting and growth of POAF populations over the course of three cutting cycles and four harvests, reporting median values from 100 simulations for commercial density and volume recovery. Analysis of the available long-term forest monitoring data in MUZ concessions indicates that application of this model is valid in Petén.

The model used for *Cedrela* and the three lesser-known species simulates population responses after the original harvest (2005/2006) and a single cutting cycle. The lack of empirical knowledge regarding seedling, sapling, and pole-sized tree dynamic rates (survival, diameter growth) of these four species limited the ability to simulate population dynamics beyond the second harvest.

Results and Discussion

The core question guiding study design and analysis was the following: Are current forest management practices in the MBR sustainable? It was assumed that 'sustainable' means 'sustained timber yield over multiple harvests' of the five timber species that currently generate the majority of income for forest concessions in the region. The best available empirical knowledge was applied through use of life history-based models to simulate population dynamics of both observed and estimated species' population structures in 2005 and 2006 POAFs in 11 concessions, representing most of the production forests in the MUZ of the MBR. Overall, simulation outcomes indicate that management practices are well matched to species' population structures and dynamics. Below some nuances and implications of these findings are discussed, along with issues to consider for future forest management in the MBR.

Mahogany

This report emphasizes outcomes for mahogany because this species generates the lion's share of revenue from MUZ forests compared to all other timber species combined, as mahogany does wherever it occurs. Unless markets change radically, the future of natural forest management and CFE development in the MBR depends on the sustainability of mahogany harvests.

While simulation outcomes for mahogany populations in MUZ POAFs indicate a range of future-harvest outcomes, in most cases current forest management practices appear sustainable over the long term. This is a truly remarkable result considering the history of mahogany's exploitation across its vast Central and South American range, throughout which it has largely been treated as a non-renewable resource best suited for small-scale and industrial mining until populations reach a point approaching commercial extinction.

The positive outcomes in the MBR derive from two main sources: extremely favorable population densities and structures across much of the MUZ landscape, and a method for calculating cutting intensity that is based on biological reality rather than on short-term financial exigency. With some exceptions, mahogany population structures in MBR concessions are generally weighted towards sub-commercial and juvenile (<30 cm diameter) size classes, meaning that future commercial populations are already in place in the forest at the time of first harvest. Basing allowable cutting intensities on expected growth and recruitment by inventoried populations of sub-commercial trees is both intuitively obvious, and exceptionally rare in the world of tropical forest management.

Assisted regeneration in the Carmelita forest concession

Photo by Sergio Izquierdo

To understand just how remarkable the Guatemalan forest management scenario for mahogany is, consider how things work in Brazil, where the vast majority of natural forest mahogany populations originally occurred (Grogan et al. 2010). There, forest management parameters include: a minimum diameter cutting limit of 60 cm, the same as most concessions in the MUZ; a minimum retention rate of 20 percent of commercial-sized trees; a landscape-scale minimum retention density of five commercial-sized trees per 100 ha; and cutting cycles of 25–30 years.

Under such rules, mahogany populations in Brazil cannot recover initial densities during cutting cycles between harvests, and timber production during future harvests falls precipitously. Indeed, when Brazilian mahogany populations are logged repeatedly at 80 percent intensity, only the minimum retention density rule of five commercial-sized trees per 100 ha prevents their complete commercial extirpation. Part of the problem in Brazil is that population structures tend to be weighted more towards commercial size classes than MUZ populations, meaning that recruitment to commercial size by sub-commercial trees is relatively slow because there are fewer individuals available to replace harvested trees. However, the main source of these outcomes is a one-size-fits-all-populations rule for cutting intensity that bears no relation to biological reality. This underscores yet again the laudability of CONAP and the concession's approach of tying cutting intensities to biological reality rather than arbitrary variables.

This study's transect data for mahogany seedlings, saplings, and poles provides abundant support for future harvest scenarios. Transect data from harvested 2005/2006 POAFs present, on average, higher densities of juvenile stems than from 'undisturbed' or 'natural' 2015 POAFs. This means that most regeneration encountered in logged POAFs dates to the harvest event or earlier because removing commercial trees reduces the availability of seeds in subsequent years. The higher comparative densities in logged forest disappear in larger size classes (pole-sized stems >10 cm diameter and larger) because these individuals originated before harvests in 2005 and 2006.

This implies that, first, logging apparently encourages higher densities of mahogany regeneration because the disturbance, which opens canopy gaps and ground-level growing space, encourages seedling establishment and early growth. Second, these higher seedling and sapling densities are available for application of silvicultural practices intended to accelerate growth rates should the forestry industry and forest communities choose to invest in these practices.

Spanish cedar, manchiche, pucté and santa maría

Simulation outcomes for Spanish cedar, *Lonchocarpus, Bucida,* and *Calophyllum* were highly variable, but generally positive in terms of commercial density recovery during the first cutting cycle. However, availability of production volumes of these species at the time of second harvest is more uncertain. All four of these species occur at lower commercial densities than mahogany, especially Spanish cedar. Additionally, all four species, especially *Bucida*, are more spatially patchy at the landscape scale, possibly related to more specialized habitat or site requirements for seedling establishment, growth, and recruitment. Combined with their lower economic value, these issues make it challenging for forest managers to adequately quantify their population structures and the vital demographic rates (annual growth, mortality, seed production, etc.) that will ultimately determine future harvest outcomes.

Mahogany seed tree marked with an "S" (*semilla*), to be left unharvested and protected for future stock

Photo by Sergio Izquierdo

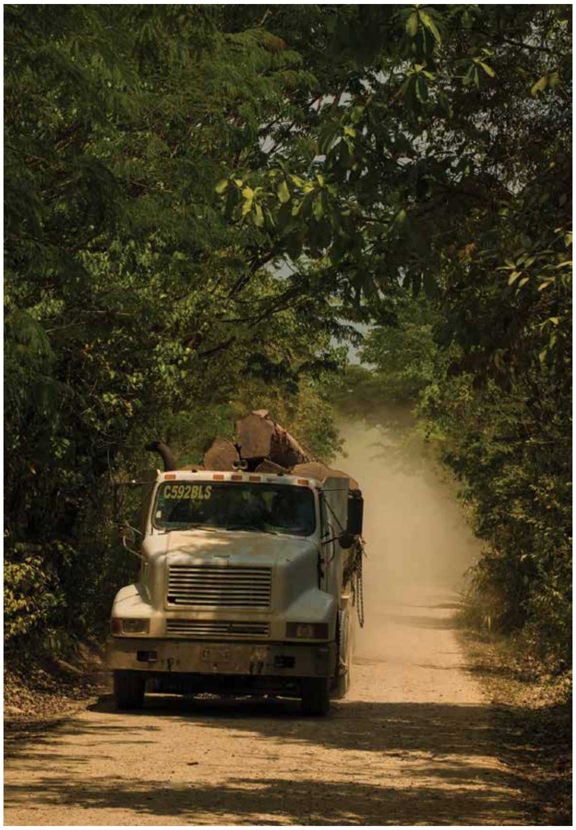
The five-year plan inventory data proved inadequate for use in simulating population responses to harvests. Most populations with only five-year plan data available for sub-commercial trees demonstrated extremely high commercial density recovery during a single cutting cycle, suggesting that these data, while perhaps applicable in some cases, are broadly inadequate for longer-term simulation purposes. One-hundred-percent-area inventories for sub-commercial and commercial trees have been repeatedly proven to be cost-effective in tropical forest management.

Implications for management

Cutting Intensity

The rate of recovery by commercial timber species following one or more harvests depends a great deal on cutting intensities and the assumptions that underpin them. Under Guatemalan regulations, cutting intensities in MUZ concessions for all five species considered here ostensibly depend on recruitment rates by sub-commercial trees into commercial size classes. This remarkably rigorous practice should guarantee sustained timber yields over multiple harvests. However, two issues must be resolved for harvest rates to be in equilibrium with species' population dynamics. First, the formula for calculating cutting intensity should represent growth and mortality rates by sub-commercial trees of each species as accurately as possible. Second, assuming that cutting intensity calculations approximate reality reasonably well, forest managers and CONAP must limit harvests to levels that can be recovered during successive cutting cycles – that is, actual cutting intensities should equal *targeted* values calculated based on the formula.

Cutting intensity for all five species is currently calculated assuming the same median diameter growth rate (0.4 cm year^{-1}) for trees of all sizes in each POAF. Whether the current formula is the best solution to a very complex problem is an open question. For a given species, diameter growth rates may vary markedly as a function of stem size (diameter), recent growth history, degree of crown vine coverage, crown status, and recent fruiting history, to name just a few variables (Grogan & Landis 2009). Further, it is clear that populations of a given species may vary in diameter growth rates at local and regional scales. In addition, the formula does not account for mortality that inevitably slows recruitment by sub-commercial trees over decadal timeframes. Notwithstanding such limitations, the current approach to calculating cutting intensities is likely to sustain harvests over the long term.


Transport of harvested logs out of the MUZ in the dry season
Photo by Sergio Izquierdo

Minimum diameter cutting limit

CONAP permits forest managers in MBR concessions flexibility in determining minimum diameter cutting limit (MDCL) for each timber species, which can change from year to year. This is an unusual and laudable arrangement compared to standard practice across the tropics, where 'one-size-fits-all' rules more typically determine MDCL for broad classes of timber. For canopy-emergent species, like mahogany and Spanish cedar, which have significant proportions of sapwood until they reach larger size, an MDCL of 60 cm (occasionally 55 cm) balances the imperative to maximize productivity versus the diminishing proportion of heartwood from smaller trees. Smaller MDCL for the other three lesser-known species is warranted because these do not typically grow as large, with fewer trees >60 cm diameter relative to those smaller than this size. Trees as small as 45 cm of all three species presumably yield reasonable quantities of commercial heartwood.

How low can (or should) MDCL go? For mahogany, lowering MDCL below 60 cm diameter introduces a trade-off in reproductive capacity: trees smaller than this size have not yet attained adult reproductive stature; that is, seed production by trees smaller than this size is low, on average, compared to larger adults (Gullison et al. 1996, Snook et al. 2005, Grogan & Galvão 2006a). Since natural forest management relies for future harvests on natural regeneration, reducing reproductive capacity can lead to reduced recruitment by juvenile trees to commercial size, diminishing future harvests.

Cutting cycle

Allowing populations longer recovery times between harvests leads to higher commercial density and timber production rates over an equivalent number of cutting cycles. For mahogany, 40-year cutting cycles yielded higher rates of commercial density recovery over the course of three cutting cycles than 30- or 25-year cutting cycles. However, whether total production differs depending on cutting cycle length over equivalent timeframes was not tested: for example, whether production from three 40-year cutting cycles will be similar to production from four 30-year cutting cycles from a given concession. This is a question that could be usefully addressed in a future analysis.

An important issue for concession owners in the MUZ is the divorce between concession contract periods and the explicit expectation that forest management practices be sustainable. Current contracts run for 25 years and the power to renew them lies with CONAP; the Guatemalan Congress also has the power to revoke concessions at any time. Thus, concessionaires have no certainty as to whether they will manage the forest beyond a single cutting cycle.

This places a burden of 'best behavior' on concession managers who have no guarantee that they will reap the future benefits of today's management practices, and reduces incentives to invest in silvicultural interventions that could increase population density and/or promote tree growth and seed dispersal. Strengthening the legal basis for the concessions, signaling intent to extend the concessions beyond their current contracts based on performance-based analyses such as the present study, and extending the time horizon of contracts to correspond to cutting cycles would increase security and incentives to continue practicing good forestry.

Regeneration

Transect surveys installed during May–June 2014 generated empirical data for seedlings, saplings, and pole-sized trees that was crucial for modeling mahogany's population response to repeated harvests.

For mahogany in particular, seedling, sapling and pole densities were relatively high in many POAFs, and rarely absent altogether. Generally higher seedling and sapling densities in harvested 2005/2006 POAFs compared to unharvested 2015 POAFs indicates that forest canopy disturbance associated with logging may assist post-harvest establishment and growth. Both *Bucida* and *Calophyllum* apparently experience similar post-harvest boosts in seedling and sapling densities. However, it cannot be said to what degree elevated seedling and sapling densities can be attributed to disturbance associated with logging, nor whether harvests that are more intensive would further stimulate seedling establishment and survival. Harvest intensities in the MUZ are currently relatively low, generally <3 m^3 ha^{-1}. At this landscape-scale intensity, post-harvest impacts on mahogany seedling densities will be mainly attributable to the felling and extraction of mahogany trees, not to the removal of other species that may or may not occur nearby.

High densities of natural regeneration do not guarantee that future timber harvests will equal or exceed today's. Seedlings established in the forest understory and in natural and logging gaps will survive and grow at rates reflecting their ability to tolerate and exploit growing conditions that change constantly through time; nearly 100% will die without assistance. In mahogany's case, seedlings and saplings will tend to occur in patches at small local scales, perhaps tracing a single tree's seed shadow during a harvest year when a gap opened for colonization. To promote higher regeneration rates, these patches could be located and maintained open to encourage extended growth by mahogany seedlings, much as enrichment gaps must be kept open for years after outplanting seedlings. On the other hand, enrichment plantings guarantee establishment of healthy nursery-grown seedlings (unless seeds are broadcast-sown) at known locations which can be easily re-located for tending during the decade or decades after harvests. There are significant costs and benefits associated with both management strategies.

Spatial distribution of species populations on the MUZ landscape

Results from this study are 'spatially blind', meaning that population densities are considered constant on a per-unit-area basis. In reality, species populations commonly demonstrate patterns in their spatial distributions, often related to physiographic features such as topography and or soil type. Concession forest managers are generally knowledgeable about such patterns on a species-by-species basis, and during an initial validation workshop they asked whether these patterns had been considered in the analysis. While beyond the scope of immediate objectives, commercial census data from MUZ concessions include spatial locations of all inventoried trees, offering a potentially rich resource for inquiry into production implications of species' distribution patterns.

A second spatial issue concerns the role that protected areas play in the conservation of species' ecological and genetic integrity during the coming years. Protected areas may include buffer zones adjacent to archaeological features (un-excavated Mayan mounds are common on this landscape), seasonal or aseasonal streams, areas where topographic relief is too steep or too swampy to move heavy equipment across, or areas where harvest operations would create excessive erosion. Protected areas accounted for 0–46% of individual POAF areas considered here, representing 13 percent and 14 percent of summed POAF areas in 2005 and 2006, respectively. The degree to which these non-loggable areas provide refuge for species populations will depend on many factors, among them, a) the shape, extent, and connectedness of protected areas within a given POAF; b) Whether a species demonstrates positive or negative affinity to a given type of protected area (streamside, steep slope, etc.); c) The degree to which harvest operations honor the spatial integrity of designated protected areas during first and repeated harvests.

Caveats associated with modeling population dynamics

Results from model simulations reported here represent predicted future outcomes of current forest management practices in the MUZ, based on the most up-to-date knowledge, data and assumptions available regarding mahogany and four associated timber species. Because what will happen in the future cannot be predicted with certainty, it is important that results are viewed with caution for several reasons:

- The modeling approach: Models perform only as well as their data-based algorithms describe reality. Forest ecosystems, including the hundreds of tree species that form the super-structure of tropical forests, are so complex that modeling exercises such as these require an extreme simplification of reality. However, a great deal of empirical knowledge about mahogany has accumulated in recent years from research in Mexico, Belize, Guatemala, Bolivia, and Brazil, and the model used in this study provides the best available interpretation of the current understanding of mahogany life history.

A worker at FORESCOM adds value to the timber harvested in community concessions

Photo by Sergio Izquierdo

- Source data for model algorithms: Simulation outcomes for mahogany population dynamics in the MUZ are based on growth, mortality, and reproductive rates from populations in Brazil. How transferable are these crucial rates from Brazil to Guatemala? Population-level growth and mortality rates are both highly variable and consistent in variability from region to region and locality to locality where mahogany occurs. Variability is the rule, not the exception, with local rates dependent on site factors and stochastic disturbance regimes too complex for any model to fully describe. At the same time, the mahogany growth function from Brazil almost perfectly matches growth data from MUZ concessions; data from other sites in the Maya Rainforest and Central and South America indicate a range of growth rates encompassing those from MUZ permanent plots.

- Model limitations: Simulated Brazilian mahogany populations increase gradually in density over time in the absence of logging, that is, the model is poorly constrained by observed static and dynamic rates (Grogan et al. 2014). It is not known whether this expansion is realistic. If it is not, which rate(s) used by the model is responsible for population expansion cannot be identified. However, while this situation is problematic for populations in Brazil, which occur at very low landscape-scale densities, such population growth rates may in fact be more realistic for Petén mahogany populations, which occur at much higher densities.

- Stochastic factors: Unforeseen forces may affect predicted future outcomes, including hurricanes, fires, changes in markets or land use, political or economic instability, or social change in the coming years and decades. Hurricane Richard, for example, which came far inland in 2010 and left swaths of extensive forest blowdown and associated damage on the eastern edge of the MUZ, appears to have negatively affected model projections for at least one concession. These natural and anthropogenic forces could be large enough to impose significant and unforeseen changes on the current status quo in the MUZ, both in terms of the forest and of the socio-economic structures driving natural resource management on this landscape.

Conclusions

Based on results presented here, and bearing associated caveats in mind, forest management practices in the Maya Biosphere Reserve MUZ represent state-of-the-art best-practices for species-level management in tropical forests. One-hundred-percent area inventories for commercial and sub-commercial trees, coupled with planned harvest operations that reduce damages to residual stems, are increasingly standard practice in species-rich forests across the tropics. Determining and actually implementing cutting intensities based on species biology represents a genuine advance towards sustained yield timber production that deserves recognition and replication in other regions. The fact that this has been achieved in a landscape under severe pressure of forest conversion, and where a majority of the area under forest management is in the hands of communities, is a globally important finding. In addition to this core conclusion, the following findings are advanced:

- With a high degree of certainty, mahogany populations will recover pre-harvest commercial densities during the first cutting cycle between harvests, on average. This outcome appears sustainable over repeated harvests under current forest management practices in the MUZ.
- Estimated densities of mahogany pole-sized trees, saplings, and seedlings in nearly all POAFs are sufficiently high to anticipate population and timber production recovery during second and third cutting cycles. Logging appears to encourage seedling establishment and short-term post-harvest growth.
- Spanish cedar populations occurring at extremely low landscape-scale densities should recover pre-harvest commercial densities during the first cutting cycle, but volume production will be much lower during second harvests compared to first harvests.
- Most *Lonchocarpus, Bucida,* and *Calophyllum* populations should also recover pre-harvest commercial densities during the first cutting cycle. Volume production will be lower, on average, during second harvests compared to first harvests, but the decline will not be as extreme as for Spanish cedar.
- The method for determining cutting intensity represents an important advance in natural forest management in the tropics, but should be improved both empirically and from a regulatory standpoint. Empirically, better understanding of diameter growth and mortality rates by subcommercial size classes is required to refine the formula on a species-by-species basis. From a regulatory standpoint, less flexibility in granting exceptions (usually allowing higher actual vs. target harvest levels) will constrain harvests in 2015 and beyond to more sustainable levels.
- The data collected until now from permanent monitoring plots are valuable but not sufficient to guide fully informed decision-making. Collection of species-level growth and mortality data from permanent monitoring plots should reflect the need for more accurate calculations of cutting intensity, and to consider adopting a calculation with size-class specific growth rates. Considerations are included in the Recommendations section below.

Recommendations

Based on these main findings, the following recommendations for concessions, CONAP and technical assistance providers are advanced:

- Ensure that incentives for long-term management are in place by extending the length of concession contracts through multiple cycles. Concessionaires currently lack strong incentives to practice sustainable forestry and collect additional long-term data because there is no legal surety that their concession contracts will be extended beyond the first harvest. A legal model harmonized with long-term incentives would give concessionaires a guarantee through multiple harvest cycles. The Guatemalan government should extend current concession contracts beyond the current 25-year time horizon to encourage even greater stability and sustainability in planning and investment, and renewed agreements should correspond more closely to concession cutting cycles.
- Improve knowledge of species' regeneration and recruitment requirements—while mahogany regeneration ecology is fairly well understood, knowledge is lacking for Spanish cedar, *Lonchocarpus, Bucida,* and *Calophyllum*, which are likely to become more important to CFEs as markets expand for these species. Better information about growth and mortality for all five species analyzed would greatly improve understanding of management outcomes and how to calculate cutting intensity. Long-term studies of mortality and diameter growth rates by trees of all sizes are relatively inexpensive but require annual attention and consistent implementation. Relevant questions include:
    - Should units of observation (individual trees) be grouped by local or concession-wide populations?
    - Are site differences (for example, soil type) for different populations of a given species sufficient to justify stratifying samples with the objective of creating multiple modeling platforms?
    - What additional variables should be accounted for in dynamic rate studies (for example, patterns of seasonal and annual precipitation, crown canopy position and neighborhood density, crown vine coverage, patterns of fruit production)?
    - How can data be shared and processed into useful mortality and growth algorithms for timber species in the MBR?
- Silvicultural practices designed to reduce mortality and increase growth rates by commercial, future crop, and juvenile trees should be implemented—Currently, the sole silvicultural practice is tree-felling itself. Pre- and post-harvest vine cutting to free crowns of commercial species is the single most effective way to reduce mortality and accelerate long-term diameter growth rates.
    - For light-demanding species, canopy 'release' over concentrated patches of regeneration could encourage growth and recruitment at reasonable expense; consistent attention to growing conditions during the first 10 years after seedling establishment may be sufficient to gain canopy passage for juvenile stems.

  - In contrast to mahogany, Spanish cedar is simply rare and *Lonchocarpus*, while demonstrating high seedling density, appears to have limited ability to persist and grow through successive size classes. *Bucida* and *Calophyllum* appear to be the most likely to persist and grow once established, presenting more options for silvicultural practices aimed at reducing mortality and accelerating growth rates.
  - Silvicultural treatments should in general target abundant advance regeneration to encourage survival, growth and future timber yields.
- Improve the network of permanent monitoring plots—Supplemental monitoring should be introduced in order to increase the accuracy of cutting intensity calculations and the predictive power of model simulations for all species. Such measures should include:
  - More individuals of the target species should be monitored; for example, there were no *Cedrela* trees in the plots analyzed for this study.
  - Measurements should continue to be done on an annual basis using standardized and rigorously controlled methodologies to ensure accuracy, with training for field personnel to address the many patterns and idiosyncrasies that live trees present in the field.
  - The full range of size classes represented by a given species on the landscape, from seedling to large adult, should be included.
  - Survival/mortality should be included as a standard annual observation.
  - Quality control protocols should be incorporated to ensure that data quality matches the important role this data will play in determining sustainable harvest levels.
- The systematic sampling of juvenile stems (seedlings, saplings, pole-sized trees) and the use of a tailored, user-friendly version of the model applied here should be incorporated into annual management operations and decision-making. The sampling effort in May – June 2014 that produced the data necessary for model simulations reported here was large (265 1-ha transects in 33 POAFs) and expensive, but only because POAFs across the entire MBR had to be surveyed in a short time using a new and seemingly elaborate field protocol. Incorporating transect surveys into standard operational protocols for 5-year plan or annual POAF preparation would make them less expensive—field crews could be smaller, transportation expenses would decline, logistics would be easier—and, over time, more efficient as sampling methods evolve.
- Implement target cutting intensities more consistently. Approving extraction of extra volume from a "non-recoverable basal area" is likely to produce population declines over time; adjustments to cutting intensity should be approved with caution if at all and be attached to requirements for silvicultural treatment that will accelerate recuperation of the basal area.

ANNEX I

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